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CERTIFICATE

I, Hajime Kuramasu, residing at 1-1,036-14, Ogawa-cho, Kodaira-shi, Tokyo, 187-0032 Japan, hereby certify that I am the translator of the attached document, namely a Certified Copy of Japanese Patent Application No. 8-279388 and certify that the following is a true translation to the best of my knowledge and belief.

Hajime Kuramasu — Signature of Translator

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[Title of the Invention] LIQUID CRYSTAL PANEL SUBSTRATE, LIQUID CRYSTAL PANEL, AND ELECTRONIC DEVICE AND PROJECTION DISPLAY DEVICE

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[Title of the Invention] LIQUID CRYSTAL PANEL SUBSTRATE, LIQUID CRYSTAL PANEL, AND ELECTRONIC DEVICE AND PROJECTION DISPLAY DEVICE

[Claims]

[Claim 1] A liquid crystal panel substrate comprising a matrix of reflecting electrodes being formed on a semiconductor substrate and a transistor being formed in response to each reflecting electrode, a voltage being applied to said reflecting electrodes through said respective transistors, wherein a passivation film is formed on said reflecting electrodes.

[Claim 2] A liquid crystal panel substrate according to claim 1, wherein said passivation film is a silicon oxide film having a thickness of 500 to 2,000 angstroms.

[Claim 3] A liquid crystal panel substrate according to either claim 1 or claim 2, wherein the thickness of said passivation film is set to an adequate range in response to the wavelengths of incident light.

[Claim 4] A liquid crystal panel substrate according to either claim 2 or claim 3, wherein the thickness of said silicon oxide film as said passivation film is 900 to 1,200 angstroms when blue light is reflected.

[Claim 5] A liquid crystal panel substrate according to either claim 2 or claim 3, wherein the thickness of said silicon oxide film as said passivation film is 1,200 to 1,600 angstroms when green light is reflected.

[Claim 6] A liquid crystal panel substrate according to either claim 2 or claim 3, wherein the thickness of said silicon oxide film as said passivation film is 1,300 to 1,900 angstroms when red light is reflected.

[Claim 7] A liquid crystal panel substrate according to any one of claims 4 to 6, wherein an alignment film having a thickness of 300 to 1,400 angstroms is formed on said silicon oxide film.

[Claim 8] A liquid crystal panel substrate according to any one of claims 1 to 7, wherein a pixel region in which a matrix of pixels comprising said reflecting electrodes and said respective transistor connected to said reflecting electrodes is formed on said semiconductor substrate, and a peripheral circuit for supplying signals to a data line and a gate line connected to the transistor in said pixel region is formed outside of this;

wherein a passivation film comprising a silicon oxide film is formed above said pixel region, and

a passivation film comprising a silicon nitride film is formed above said peripheral circuit.

[Claim 9] A liquid crystal panel substrate according to any one of claims 2 to 8, wherein a silicon nitride film is formed as an insulating interlayer between said reflection electrode and a metal layer thereunder.

[Claim 10] A liquid crystal panel substrate according to any one of claims 2 to 9, wherein a laminated protective structure comprising a silicon nitride film formed on said

passivation film comprising said silicon oxide film is provided at the edge of a laminate of an insulating underlayer formed on the peripheral region of said pixel region and a metal layer optically shielding said peripheral region.

[Claim 11] A liquid crystal panel comprising a liquid crystal panel substrate described in any one of claims 1 to 10, a transparent substrate at the incident side having a counter electrode opposed at a given distance, and a liquid crystal encapsulated into the gap between said liquid crystal panel substrate and said transparent substrate.

[Claim 12] An electronic device provided with a liquid crystal panel described in claim 11 as a display section.

[Claim 13] A projection display device comprising a light source, a reflective liquid crystal panel described in claim 11 for modulating the light from said light source, and a projection lens for projecting the light modulated by said reflective liquid crystal panel.

[Claim 14] A projection display device comprising a color separation means for separating the light from said light source into three primaries, a first reflective liquid crystal panel described in claim 11 for modulating the red light separated by said color separation means, a second reflective liquid crystal panel described in claim 11 for modulating the green light separated by said color separation means, a third reflective liquid crystal panel described in claim 11 for modulating the blue light

separated by said color separation means, the thickness of the silicon oxide film forming a passivation film of said first reflective liquid crystal panel being in a range of 1,300 to 1,900 angstroms, the thickness of the silicon oxide film forming a passivation film of said second reflective liquid crystal panel being in a range of 1,200 to 1,600 angstroms, and the thickness of the silicon oxide film forming a passivation film of said third reflective liquid crystal panel being in a range of 900 to 1,200 angstroms.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention]

The present invention relates to liquid crystal panels and reflective liquid crystal panels, and in particular, a technology suitable for active matrix liquid crystal panels for switching pixel electrodes with metal oxide semiconductor field effect transistors (hereinafter referred to as MOSFETs) formed on a semiconductor substrate.

[0002]

[Description of the Related Art]

Liquid crystal panels having a structure in which a thin film transistor (TFT) array using amorphous silicon is formed on a glass substrate have been conventionally used as reflective active matrix liquid crystal panels which are used in light valves of projection display devices.

[0003]

[Problems to be Solved by the Invention]

In the active matrix liquid crystal panel using the TFT, the mobility in the TFT is low and the size of the device is large. Hence, in a projection display apparatus, such as a video projector, provided with the active matrix liquid crystal panel as light valves, an increase in the size of the apparatus is inevitable. In transmissive liquid crystal panels, since the TFT region, which is provided in each pixel, is not a transparent region, it has a serious defect that the aperture ratio decreases as the resolution of the panel is improved to XGA, or S-VGA.

[0004]

As a liquid crystal panel having a smaller size than the transmissive active matrix liquid crystal panel, a reflective active matrix liquid crystal panel in which pixel electrodes, as reflecting electrodes, are switched with a MOFSET array formed on a semiconductor substrate has been proposed.

[0005]

In such a reflective liquid crystal panel, the formation of a passivation film as a protective film on the substrate is often omitted since it is not always necessary. The formation of a passivation film, however, evidently improves reliability of the panel. The present inventor has studied the formation of a passivation film on a reflective liquid crystal panel substrate. In general, a silicon nitride film formed by a reduced pressure CVD process is often used as a passivation film in semiconductor devices.

The passivation film formed by a current CVD process inevitably has some variation of the thickness of approximately 10%. Accordingly, the reflective liquid crystal panel has disadvantages, e.g. the reflectance noticeably varies or the refractive index of the liquid crystal varies with variation of the thickness of the passivation film.

[0006]

It is an object of the present invention to provide a reflective liquid crystal panel substrate and a liquid crystal panel having a passivation film which does not cause a significant variation of the reflectance and a variation of the refractive index of the liquid crystal, and having high reliability.

[0007]

It is another object of the present invention to provide a reflective liquid crystal panel having high reliability and excellent image quality and an electronic device using the same.

[0008]

[Means for Solving the Problem]

The present invention for achieving the above object is characterized in that a silicon oxide film having a thickness of 500 to 2,000 angstroms is used as a passivation film of a reflective liquid crystal panel substrate. Although the silicon oxide film functions as a protective film slightly inferior to the silicon nitride film, it less

affects the reflectance of the pixel electrode due to variation of the film thickness compared to the silicon nitride film and a silicon oxide film having a thickness of 500 to 2,000 angstroms has a particularly slight dependency of the reflectance on the wavelength. The use of the silicon oxide film as a passivation film therefore can reduce variation of the reflectance.

[0009]

Further, the thickness of the passivation film is set to an adequate range in response to the wavelengths of incident light. In detail, the thickness of the silicon oxide film as the passivation film is 900 to 1,200 angstroms for a pixel electrode reflecting blue light, 1,200 to 1,600 angstroms for a pixel electrode reflecting green light, and 1,300 to 1,900 angstroms for a pixel electrode reflecting red light. When the thickness of the silicon oxide film as the passivation film is set to the above range, variation of the reflectance for each color can be suppressed to 1% or less, reliability of the liquid crystal panel is improved and the image quality is improved in a projection display device using the reflecting liquid crystal panel as a light valve.

[0010]

It is preferred that the thickness of the silicon oxide film as the passivation film be determined in consideration of the thickness of an alignment film formed thereon. In this case, the alignment film has a thickness of preferably

300 to 1,400 angstroms, and more preferably 800 to 1,400 angstroms. Variation of the refractive index of the liquid crystal can be effectively suppressed by setting the thickness of the alignment film to the above-mentioned range.

[0011]

In a reflective liquid crystal panel having a pixel region in which a matrix of pixel electrodes are disposed and peripheral circuits, such as a shift resistor and a control circuit, formed on the same substrate, a passivation film composed of a silicon oxide film may be formed above the pixel region and a passivation film composed of a silicon nitride film may be formed above the peripheral circuits. Since the thickness of the passivation film above the peripheral circuit does not affect the reflectance, the use of the silicon nitride film ensures protection of the peripheral circuits and improves reliability.

[0012]

A silicon nitride film may be provided as an insulating interlayer between the reflecting electrode and the metal layer thereunder, instead of the formation of the passivation film on the reflecting electrode or by using together with the passivation film composed of the silicon oxide film. The wet resistance is thereby improved and the MOSFET for pixel switching and the holding capacitor can be prevented from corroding due to water or the like.

[0013]

A monolithic protective structure in which a silicon nitride film formed on a passivation film of silicon oxide is provided over the edge and the side wall of the laminate of the transistor for switching the pixel, and the insulating interlayer and metal layer which form a wire region supplying a given voltage and signal to the transistor. The waterproof property is thereby improved at the edge of the liquid crystal panel in which water readily penetrates, and the durability is also improved since it acts as a reinforcing material.

[0014]

[Description of the Embodiments]

Preferred embodiments in accordance with the present invention will now be described with reference to the drawings.

[0015]

Figures 1 and 3 show a first embodiment of a reflecting electrode substrate of a reflective liquid crystal panel in accordance with the present invention. Figures 1 and 3 are a cross-sectional view and a planar layout view, respectively, of one pixel section among a matrix of pixels. Figure 1(a) is a cross-sectional view taken along section line I-I of Figure 3. Figure 1(b) is a cross-sectional view taken along section line II-II of Figure 3.

[0016]

In Figure 1, identification numeral 1 represents a P-type semiconductor substrate such as single-crystal silicon

(or N-type semiconductor substrate (N--)), identification numeral 2 represents a P-type well region formed on the surface of the semiconductor substrate 1, and identification numeral 3 represents a field oxide film for separating elements (so called LOCOS) formed on the surface of the semiconductor substrate 1. The well region 2 is formed as a common well region of a pixel region in which a matrix of pixels of, for example, 768 by 1,024 is provided, and is not limited to this, and, as shown in Figure 5, is separately formed from a well region in which peripheral circuits, such as a data line driving circuit 21, a gate line driving circuit 22, an input circuit 23 and a timing control circuit 24 are formed. The field oxide film 3 is formed into a thickness of 5,000 to 7,000 angstroms by selective thermal oxidation.

[0017]

Two openings per pixel are formed in the field oxidation film 3. In the center of one opening a gate electrode 4a composed of polysilicon or metal silicide is formed with a gate oxide film (insulating film) 4b formed therebetween, source and drain regions 5a and 5b composed of N-type impurity doping layers (hereinafter referred to as doping layers) having high impurity contents are formed on the substrate surface at both sides of the gate electrode 4a, and a MOSFET is thereby formed. The gate electrode 4a extends to the scanning direction (pixel line direction) to form a gate line 4.

[0018]

On the substrate surface in the other opening formed in the field oxide film 3, a P-type doping region 8 is formed. On the surface of the P-type doping region 8, an electrode 9a composed of polysilicon or metal silicide is formed with an insulating film 9b formed therebetween. An insulating film capacitor is formed between the electrode 9a and the P-type doping region 8. The electrode 9a and the polysilicon or metal silicide layer as the gate electrode 4a of the MOSFET can be formed by the same process, and the insulating film 9b under the electrode 9a and the insulating film as the gate insulating film 4a can be formed by the same process.

[0019]

The insulating films 4b and 9b are formed on the semiconductor substrate surface in the openings by thermal oxidation into a thickness of 400 to 800 angstroms. The electrodes 4a and 9a have a structure in which a poly-silicon layer having a thickness of 1,000 to 2,000 angstroms is formed and a silicide layer of a high boiling point metal such as Mo or W having a thickness of 1,000 to 3,000 angstroms is formed thereon. The source and drain regions 5a and 5b are formed by means of self-alignment by implanting an N-type impurity on the substrate surface at both sides of the gate electrode 4a as a mask by ion plating.

[0020]

The above-mentioned P-type doping region 8 may be formed by, for example, a doping treatment including exclusive ion plating and heat treatment, and may be formed by ion plating before the formation of the gate electrode. That is, after the insulating film 9b is formed, an impurity of the same polarity as the well is implanted such that the well surface has a higher impurity concentration and thus a lower resistance than those in the well. The concentration of impurities in the well region 2 is preferably $1\times10^{17}/cm^3$ or less, and more preferably $1\times10^{16}/cm^3$ to $5\times10^{16}/cm^3$. The preferred concentration of the surface impurities in the source and drain regions 5a and 5b is $1\times10^{20}/cm^3$ to $3\times10^{20}/cm^3$. Also, the concentration of the P-type doping region 8 is preferably $1\times10^{18}/cm^3$ to $5\times10^{19}/cm^3$, and more preferably $1\times10^{18}/cm^3$ to $1\times10^{19}/cm^3$ in view of reliability and voltage resistance of the insulating film forming the holding capacitance.

[0021]

A first insulating layer 6 is formed over the electrodes 4a and 9a and the field oxide film 3, a data line 7 (refer to Figure 3) which is composed of a metal layer substantially consisting of aluminum is formed on the insulating film 6, and a source electrode 7a and an auxiliary bonding wire 10 are provided so as to protrude from th data line. The source electrode 7a is electrically

connected to the source region 5a through a contact hole 6a formed in the insulating film 6, and one end of the auxiliary bounding wire 10 is electrically connected to the drain region 5b through a contact hole 6b formed in the insulating film 6.

[0022]

The insulating film 6 is formed by, for example, depositing an HTO film (a silicon oxide film formed by a high temperature CVD process) having a thickness of approximately 1,000 angstroms and depositing a BPSG film (a silicate glass film containing boron and phosphorus) having a thickness of approximately 8,000 to 10,000 angstroms. The metal layer which forms the source electrode 7a and the auxiliary bonding wire 10 has, for example, a four-layer structure of Ti/TiN/Al/TiN from the bottom. The thicknesses of the lower Ti layer, TiN layer, Al layer and upper Ti layer are 100 to 600 angstroms, approximately 1,000 angstroms, 4,000 to 10,000 angstroms and 300 to 600 angstroms, respectively.

[0023]

An second insulating interlayer 11 is formed over the source electrode 7a, the auxiliary bonding wire 10 and the insulating interlayer 6, and a light shielding film comprising a second metal layer 12 essentially consisting of aluminum is formed on the second insulating interlayer 11. The second metal layer 12 as the light shielding film is formed as a metal layer for forming bonding wires between

devices in the peripheral circuits, such as a driving circuit, which are formed on the periphery of the pixel region, as described later. No additional step is therefore required for forming only the light shielding film (12), and the process can be simplified. The light shielding film (12) is formed so as to cover the entire pixel region and has an opening 12a on the auxiliary bonding wire 10 for piercing a pillar connecting plug 15 which electrically connects a pixel electrode with a MOSFET, described later. That is, in the plan view shown in Figure 3, a rectangular frame 12a represents the above-mentioned opening and the entire outside of the opening 12a is covered with the light shielding film (12). The incident light from the upper side in Figure 1 is almost completely shielded and a leakage current flow due to light transmission in the channel region and the well region of the MOSFET for pixel switching can be prevented.

[0024]

The second insulating layer 11 is formed by, for example, depositing a silicon oxide film (herein after referred to as a TEOS film) by a plasma CVD process using TEOS (tetraethylorthosilicate) into a thickness of approximately 3,000 to 6,000 angstroms, depositing a SOG film (a spin-on-glass film), etching it by an etch-back process, and depositing a second TEOS film thereon into a thickness of approximately 2,000 to 5,000 angstroms. The second metal layer 12 as the light shielding film may have

Received at: 5:25AM, 8/10/2002

the same structure as the first metal layer (7), and may have, for example, a four layer structure of Ti/TiN/Al/TiN from the bottom. The thicknesses of the lower Ti layer, TiN layer, Al layer and upper Ti layer are 100 to 600 angstroms, approximately 1,000 angstroms, 4,000 to 10,000 angstroms and 300 to 600 angstroms, respectively.

[0025]

In this embodiment, a third insulating layer 13 is formed on the light shielding layer (12), and a rectangular pixel electrode 14 as a reflective electrode almost corresponding to one pixel is formed on the third insulating electrode 13 as shown in Figure 3. A contact hole 16 is provided in response to the opening 12a provided in the light shielding film (12) so as to pierce the third insulating interlayer 13 and the second insulating interlayer 11, and the contact hole 16 is filled with a pillar connecting plug 15 composed of a high melting point metal, such as tungsten, which electrically connects the auxiliary bonding wire 10 and the pixel electrode 14. A passivation film 17 is formed on the entire pixel electrode 14.

[0026]

The pixel electrode 14 is formed by depositing tungsten by a CVD process, smoothing tungsten and the third insulating interlayer 13 a chemical machining polishing (CMP) process, by depositing an aluminum into a thickness of 300 to 5,000 angstroms by, for example, a low temperature

sputtering process and by patterning it into a square having a side of approximately 15 to 20 μm, although the process is not for lamination. The connecting plug 15 may be formed by smoothing the third insulating interlayer by a CMP process, providing the contact hole and depositing tungsten therein. The passivation film 17 is composed of a silicon oxide film having a thickness of 500 to 2,000 angstroms in the pixel region and a silicon nitride film having a thickness of 2,000 to 10,000 angstroms in the peripheral circuits and the seal and scribe sections.

[0027]

The use of a silicon oxide film as the passivation film 17 covering the pixel region can prevent a significant change in a reflectance due to the variation of the film thickness and the wavelength of the light. Further, the passivation film 17 covering a region outside the peripheral circuit, and particularly the region, in which the liquid crystal is encapsulated (outside the seal section), may be a silicon nitride film or a double-layer protective film consisting of a silicon oxide film and a silicon nitride film thereon in order to further improve reliability, in which the silicon nitride film as a protective film is superior to the silicon oxide film. An alignment film is formed on the entire passivation film 17 and subjected to rubbing treatment when forming a liquid crystal panel.

[0028]

The thickness of the passivation film 17 can be

determined within an adequate range in response to the wavelength of the incident light. That is, the thickness of the silicon oxide as the passivation film is in a range of 900 to 1,200 angstroms for a pixel electrode reflecting blue light, 1,200 to 1,600 angstroms for a pixel electrode reflecting green light, or 1,300 to 1,900 angstroms for a pixel electrode reflecting red light. A thickness of the silicon oxide film as the passivation film set to within the range can suppress the variation of the reflectance in the reflective electrode composed of aluminum to 1% or less. The ground is illustrated below.

[0029]

Figures 10 and 11 show the results of dependency of the reflectance of the aluminum electrode on the thickness of the silicon oxide film at different wavelengths. In Figure 10, symbol ◇ represents reflectance at a thickness of 500 angstroms, symbol □ represents reflectance at a thickness of 1,000 angstroms, symbol ▲ represents reflectance at a thickness of 1,500 angstroms, and symbol × represents reflectance at a thickness of 2,000 angstroms. In Figure 11, symbol ◇ represents reflectance at a thickness of 1,000 angstroms, symbol □ represents reflectance at a thickness of 2,000 angstroms, symbol ▲ represents reflectance at a thickness of 4,000 angstroms, and symbol × represents reflectance at a thickness of 8,000 angstroms.

Received at: 5:25AM, 8/10/2002
2002年 8月10日 18時15分

[0030]

As evidently shown in Figure 11, at a thickness of 4,000 angstroms the reflectance decreases approximately 3% from 0.89 to 0.86 as the wavelength changes from 450 nm to 550 nm and the reflectance decreases approximately 8% from 0.85 to 0.77 as the wavelength changes from 700 nm to 800 nm. At a thickness of 8,000 angstroms the reflectance decreases approximately 3% from 0.89 to 0.86 as the wavelength changes from 500 nm to 600 nm and the reflectance decreases approximately 6% from 0.86 to 0.80 as the wavelength changes from 650 nm to 750 nm. In contrast, no significant changes are observed at a thickness of 500 angstroms, 1,000 angstroms, 1,500 angstroms or 2,000 angstroms. These results illustrate that the effective thickness of the silicon oxide film is in a range of 500 to 2,000 angstroms.

[0031]

Figures 10 and 11 also demonstrate that the reflectance slightly changes in a specified thickness range of the silicon oxide film. When reflective liquid crystal panels are used for a projection display apparatus, three panels are used in response to three primaries, red, blue and green. The present inventor further studied an optimum thickness range of the silicon oxide film for each color. The results are shown in Figures 12 to 14. Figure 12 is a graph illustrating reflectances at various thicknesses of the silicon oxide film in a wavelength range of 420 to 520

nm for blue light and its neighbor, Figure 13 is a graph illustrating reflectances at various thicknesses of the silicon oxide film in a wavelength range of 500 to 600 nm for green light and its neighbor, and Figure 14 is a graph illustrating reflectances at various thicknesses of the silicon oxide film in a wavelength range of 560 to 660 nm for red light and its neighbor.

[0032]

Figure 12 demonstrates that at a thickness of 800 angstroms the reflectance decreases by approximately 1.1% from 0.896 to 0.882 as the wavelength changes from 440 nm to 500 nm. At a thickness of 1,300 angstroms, the reflectance changes by approximately 0.6% from 0.887 to 0.893 as the wavelength changes from 420 nm to 470 nm and the reflectance is noticeably lower than those at other thicknesses within a wavelength of 420 to 450 nm. In contrast, no significant changes in reflectance are observed and a satisfactorily high reflectance is achieved at a thickness of 900 angstroms, 1,000 angstroms, 1,100 angstroms or 1,200 angstroms.

[0033]

As shown in Figure 13, at a thickness of 1,100 angstroms the reflectance decreases by approximately 1.6% from 0.882 to 0.866 as the wavelength changes from 550 nm to 600 nm. At a thickness of 1,700 angstroms the reflectance is considerably lower than those at other thicknesses within a wavelength of 500 nm to 530 nm. In contrast, no

significant changes in reflectance are observed and a satisfactorily high reflectance is achieved at a thickness of 1,250 angstroms, 1,400 angstroms or 1,550 angstroms.

[0034]

As shown in Figure 14, at a thickness of 1,200 angstroms the reflectance decreases by approximately 3.4% from 0.882 to 0.848 as the wavelength changes from 560 nm to 660 nm. At a thickness of 2,000 angstroms the reflectance is considerably lower than those at other thicknesses within a wavelength of 560 nm to 610 nm. In contrast, no significant changes in reflectance are observed and a satisfactorily high reflectance is achieved at a thickness of 1,400 angstroms, 1,600 angstroms or 1,800 angstroms.

[0035]

Figures 12 to 14 demonstrate that when a thickness of the silicon oxide film as the passivation film is set to within the range of 900 to 1,200 angstroms for a pixel electrode which reflects blue light, 1,200 to 1,600 angstroms for a pixel electrode which reflects green light or 1,300 to 1,900 angstroms for a pixel electrode which reflects red light, the variation of the reflectance for each color can be suppressed to 1% or less and a satisfactorily high reflectance can be achieved.

[0036]

Each of the graphs shown in Figures 12 to 14 shows the reflectance when a polyimide alignment film is formed with a thickness of 1,100 angstroms on the passivation film. The

optimum thickness range of the silicon oxide film slightly shifts with a different thickness of the alignment film. Regarding the thickness range of the alignment film, it is preferred that the thickness of the alignment film be within a range of 800 to 1,400 angstroms in view of suppressing the variation of refractive index of the liquid crystal. When the thickness of the alignment film is within the above-mentioned range and the thickness of the silicon oxide film in the liquid crystal panel for each color is within the above-mentioned range, the variation of the reflectance can be satisfactorily suppressed to 1% or less.

[0037]

The above description was proceeded according to a configuration where an RGB color filter is formed on the inner face of the opposing substrate of a liquid crystal panel in response to pixel electrodes and the color light passing through the color filter is reflected from the pixel electrode. When a liquid crystal panel for reflecting red light, a liquid crystal panel for reflecting blue light and a liquid crystal panel for reflecting blue light are provided in the apparatus, such as a projection display device as described later, it is preferred that the thickness of the silicon oxide film as the passivation film of the liquid crystal panel for red light be set a range from 1,300 to 1,900 angstroms, the thickness of the silicon oxide film as the passivation film of the liquid crystal panel for green light be set a range from 1,200 to 1,600

angstroms and the thickness of the silicon oxide film as the passivation film of the liquid crystal panel for blue light be set a range from 900 to 1,200 angstroms.

[0038]

Figure 3 is a planar layout view of the liquid crystal substrate at the reflection side shown in Figure 1. As shown in Figure 3, the data line 7 and the gate line 4 are formed so as to cross each other in this embodiment, a channel region of MOSFET for pixel switching is provided under the gate line at the hatched region H, the gate line 4 functions as the gate electrode 4a, and the source and drain regions 5a and 5b are formed on both sides (at the upper and lower sides in Figure 3) of the channel region 5c. The source electrode 7a connecting to the data line is formed so as to protrude from the data line 7, extended along the vertical direction in Figure 3, and is connected to the source region 5a of the MOSFET through the contact hole.

[0039]

The P-type doping region 8 forming one terminal of the holding capacitor is formed so as to link to the P-type doping region in the adjacent pixel in the direction parallel to the gate line 4. It is connected to a power line 70 provided outside the pixel region through contact holes 71 to apply a given voltage V_{ss}, such as 0 volt. As a result, the potential of one electrode of the holding capacitor can be stabilized and undesirable variation in the voltage of the pixel electrode can be prevented. Since the

P-type doping region 8 is provided near the MOSFET and the voltage of the P well is simultaneously fixed, the substrate voltage of the MOSFET is stabilized and variation of the threshold voltage due to the back gate effect can be prevented.

[0040]

Although not shown in the drawings, the power line 70 is also used as a line which supplies a given voltage V_{SS} as a well voltage to the P-type well region in the peripheral circuit provided outside the pixel region. The power line 70 is formed of the first metal layer which is the same as the data line 7. Each pixel electrode 14 has a rectangular shape and is closely provided to the adjacent pixel electrode 14 at a give distance, for example, 1 µm, so as to decrease the light which leaks between the pixel electrodes as much as possible. Although the center of the pixel electrode is shifted from the center of the contact hole 16 in the drawings, it is preferable that the center of the pixel electrode and the center of the contact hole 16 substantially agree with each other, because the distance in which the light incident from the gap with the adjacent pixel reaches the contact hole is almost equalized at the edge of each pixel electrode and leakage of the light is decreased.

[0041]

Although the above-mentioned embodiment includes the N-channel-type MOSFET for pixel switching and the P-type

doping layer of semiconductor region (8) as one electrode of the holding capacitor, an N-type well region, a P-channel-type MOSFET for pixel switching and an N-type doping layer of semiconductor region as one electrode of the holding capacitance are also available. In this case, it is preferable that a given voltage be applied to the N-type doping layer as one electrode of the holding capacitor as in the N-type well region.

[0042]

A high voltage, e.g. 15 volts, is applied to the gate electrode 4a of the MOSFET for pixel switching, whereas the peripheral circuit is driven by a low voltage, e.g. 5 volts. It is conceivable that the thickness of the gate insulating film in the FET forming the peripheral circuit be small than that of the gate insulating film of the FET for pixel switching in order to improve the characteristics of the FET and increase the operation rate of the peripheral circuit. When such a technology is applied, the thickness of the gate insulating film of the FET forming the peripheral circuit can be reduced to approximately one third to one fifth the thickness of the gate insulating film of the FET for pixel switching (for example, 80 to 200 angstroms) in view of voltage resistance of the gate insulating film.

[0043]

In the first embodiment, a voltage applied between the electrodes of the holding capacitor is only five volts which is the difference between the image signal voltage Vd

applied to the data line and the central voltage Vc of the image signals (an LC common voltage LC-COM applied to a counter electrode 33 provided on the counter substrate 35 of the liquid crystal panel in Figure 6 is shifted by ΔV from Vc, and the voltage practically applied to the pixel electrode is also shifted by ΔV and becomes V_d-ΔV). In the first embodiment, by simultaneously forming the insulating film 9b just below the polysilicon or metal silicide layer as one electrode 9a of the holding capacitor with the gate insulating film of the FET forming a peripheral circuit, the thickness of the insulating film in the holding capacitor can be reduced to one third to one fifth compared to the above-mentioned embodiment, hence the capacitance can be increased by three to five times. In this case, the doping region 8 forming one terminal of the holding capacitor must be set to be reverse polarity to the well (N-type for the P-type well) and it must be connected to a voltage of near Vc or LC-COM at the periphery of the pixel region so as to hold a voltage different from the well voltage (for example, Vss for the P-type well). In Figure 7, V_G represents the voltage applied to the gate line 4, the term tH1 represent a selective period (scanning period) to energize the MOSFET in the pixel and the period other than the selective period is a nonselective period not to energize the MOSFET in the pixel.

[0044]

One electrode 9a of the holding capacitor may be made

of a polysilicon or metal silicide layer which forms the gate electrode of the MOSFET forming the peripheral circuit, instead of the polysilicon or metal silicide layer forming the gate electrode of the FET for pixel switching. In this case, the doping region 8 forming one terminal of the holding capacitor must be set to be reverse polarity to the well (N-type for the P-type well) and it must be connected to a voltage of near Vc or LC-COM at the periphery of the pixel region so as to hold a voltage different from the well voltage (for example, Vss for the P-type well).

[0045]

Figure 1(b) is a cross-sectional view (section II-II in Figure 3) of the periphery of the pixel region in the embodiment in accordance with the present invention. The drawing shows a configuration in which the doping region 8 extending in the scanning direction of the pixel region (pixel line direction) is connected to a given voltage (V_{ss}). Identification number 80 represents a P-type contact region which is formed by the same step as the source/drain region of the MOSFET in the peripheral circuit, in which impurities having the same polarity is ion-implanted after the formation of the gate electrode into the doping region 8 which is formed before the formation of the gate electrode. The contact region 80 is connected to the line 70 through the contact hole 71 to apply a constant voltage V_{SS}. The contact region 80 is also shielded with a light shielding film 14' composed of a third metal layer.

[0046]

Figure 2 is a cross-sectional view of an embodiment of a CMOS circuit device forming a peripheral circuit, e.g. a driving circuit, outside the pixel region. In Figure 2, the positions having the same numbers as Figure 1 represent the metal layer, insulating film and semiconductor region which are formed by the same step.

[0047]

In Figure 2, identification numbers 4a and 4a' represent gate electrodes of an N-channel MOSFET and a P-channel MOSFET forming a peripheral circuit (CMOS circuit), respectively, identification numbers 5a (5b) and 5a' (5b') represent an N-type doping region and a P-type doping region, respectively, as their respective source and drain regions, and identification numbers 5c and 5c' represent their respective channel regions. The contact region 80 for supplying a constant voltage to the P-type doping region 8 which functions as one electrode of the holding capacitor in Figure 1 is formed by the same step as the P-type doping region 5a' (5b') which functions as the source (drain) region of the P-channel MOSFET. Identification numbers 27a and 27c represent source electrodes formed by the first metal layer and connected to the power voltage (any one of 0 volt, 5 volts and 15 volts), and identification number 27b represents a drain electrode formed by the first metal layer. Identification number 32a represents a wiring layer composed of the second metal layer and is used as a wire for

connecting between the devices forming a peripheral circuit. Identification number 32b also represents a power wiring layer composed of the second metal layer and functions as a light shielding film. The light shielding film 32b can be connected to any one of V_C, LC-COM, power voltage, a constant voltage, e.g. 0 volt, and a variable voltage. Identification number 14' represents a third metal layer which is used as a light shielding film in the peripheral circuit and prevents unstable voltage in the semiconductor region which is caused by carriers formed during light transmittance in the semiconductor region of the peripheral circuit. Accordingly, the peripheral circuit is also shielded from light by the second and third metal layers.

[0048]

As described above, the passivation film 17 in the peripheral circuit may be a protective film composed of a silicon nitride film or a double-layered film of silicon oxide and silicon nitride thereon, in which the silicon nitride protective film is superior to the silicon oxide film as the passivation film in the pixel region. The source/drain region of the MOSFET forming the peripheral circuit of this embodiment may be formed by a self-alignment process, although it not limited to this. The source/drain region of each MOSFET may have a LDD (lightly doped drain) structure or a DDD (double doped drain) structure. It is preferred that the FET for pixel switching have an offset structure in which the gate electrode is distant from the

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2002年 8月10日 18時18分

source/drain region, taking into consideration that the FET for pixel switching is driven by a high voltage and the leakage current must be prevented.

[0049]

Figure 4 shows a preferred embodiment of an edge structure of a reflecting electrode (pixel electrode) substrate. In Figure 4, the parts having the same identification numbers represent the layers and semiconductor regions formed by the same steps.

[0050]

As shown in Figure 4, the edge and the side wall of the laminate composed of the insulating interlayer and the metal layer have a monolithic protective structure in which a silicon nitride film 18 is formed on the silicon oxide passivation film 17 which covers the pixel region and the peripheral circuit. Water and the like therefore will barely penetrate from the edge, durability is improved and the yield is improved due to reinforcement of the edge. In this embodiment, a sealing material 36 for encapsulating the liquid crystal is provided on the monolithic protective structure which is perfectly planarized. The distance to the opposing substrate therefore can be maintained constant regardless of variation of the thickness whether the insulating interlayer and the metal layer are present or not. Since the above configuration permits a single-layered silicon oxide protective film on the reflecting electrode forming a pixel electrode, it can suppress a decrease in

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2002年 8月10日 18時18分

reflectance and dependence of the reflectanc on the wavelength.

[0051]

As shown in Figure 4, in this embodiment, the third metal layer 14' functions as the light shielding film of the peripheral circuit region, is connected to the wiring layer 19 formed on the surface of the semiconductor substrate 1 with the second and first metal layers 12' and 7' therebetween and is connected to a pad not shown in the drawing with the wiring layer 19 therebetween to apply a given voltage or signal. When the resistance value of the wiring layer 19 is not negligible, the first metal layer 12' or the second metal layer 7' may be directly connected to the pad.

[0052]

Figure 5 shows another embodiment in accordance with the present invention. In Figure 5, the portions having the same identification numbers as Figures 1 and 2 represent the layers and the semiconductor regions formed by the same process. In this embodiment, a silicon nitride film 13b is formed under the insulating interlayer 13a composed of the TEOS film (partly including a remaining SOG film during etching) between the reflecting electrode 14 and the light shielding layer 12 thereunder. Alternatively, a silicon nitride film 13b may be formed on the TEOS film 13a. The use of a configuration having an additional silicon nitride film inhibits penetration of water and thus improves wet

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resistance.

[0053]

Figure 6 is a planar layout of an entire liquid crystal panel substrate (reflection electrode substrate) in which the above-mentioned embodiment is applied.

[0054]

As shown in Figure 6, in this embodiment a light shielding film 25 is provided in order to shield the light incident on the peripheral circuits provided on the periphery of the substrate. The peripheral circuits are provided on the periphery of the pixel region 20 in which a matrix of the pixel electrodes is disposed, and include a data line driving circuit 21 for supplying image signals to the data line 7 in response to the image data, a gate line driving circuit 22 for sequentially scanning gate lines 4, an input circuit 23 for reading the image data from the outside through the pad region 26, and a timing control circuit 24 for controlling these circuits. These circuits are formed by combining active devices or switching devices composed of MOSFETs formed by the same step as or a different step to the MOSFET for switching the pixel electrodes and loading devices, such as resistors and capacitors.

[0055]

In this embodiment, the light shielding film 25 is composed of the third metal layer which is formed by the same step as the pixel electrode 14 shown in Figure 1 so as

to apply a given voltage, e.g. a power voltage, the central voltage V_C of the image signals or an LC common voltage. Application of the given voltage to the light shielding film 25 can reduce reflection compared to a floating voltage and other voltages. Reference numeral 26 represents a pad used for supplying the power voltage or a pad region provided with a terminal.

[0056]

Figure 7 is a cross-sectional view of a reflective liquid crystal panel using the above-mentioned liquid crystal panel substrate 31. As shown in Figure 7, a supporting substrate 32 composed of glass or ceramic is bonded to the back surface of the liquid crystal panel substrate 31 with a bonding agent. A glass substrate 35 at the incident side having a counter electrode (common electrode) composed of a transparent electrode (ITO) for applying an LC common voltage is opposed to the front surface of the liquid crystal panel substrate 31 at an adequate distance, and a well known TN (twisted nematic) liquid crystal or an SH (super homeotropic) liquid crystal 37 in which the liquid crystal molecules are substantially vertically aligned in a non-voltage applied state is encapsulated into a gap formed by sealing the periphery of the substrates with a sealing material 36 to form a liquid crystal panel 30. The position of the sealing material is determined so that the pad region 26 is located outside the sealing material 36.

[0057]

The light shielding film 25 on the peripheral circuits faces the counter electrode 33 with the liquid crystal 37 therebetween. Since the LC common voltage is applied to the counter electrode 33 when the LC common voltage is applied to the light shielding film 25, no direct current voltages are applied to the liquid crystal disposed therebetween. As a result, liquid crystal molecules are always twisted by approximately 90 degrees in the TN liquid crystal or always vertically aligned in the SH liquid crystal.

[0058]

In this embodiment, since the liquid crystal panel substrate 31 composed of the semiconductor substrate is bonded to the supporting substrate 32 composed of glass or ceramic at the back surface with a bonding agent, the strength is significantly enhanced. As a result, when these are bonded to the opposing substrate after the supporting substrate 32 is bonded to the liquid crystal panel substrate 31, the gap of the liquid crystal layer is equalized over the entire panel.

[0059]

Figure 9 shows an example of electronic devices using the liquid crystal panels in accordance with the present invention, and is a planar schematic diagram of the main section of a projector (projection display device) using a reflective liquid crystal panel in accordance with the present invention as a light valve. Figure 9 is a cross-

sectional view of an XZ plane which passes through the center of an optical element 130. This projector includes a light source 110 provided along the system light axis L, an integrator lens 120, a polarizing illuminator 100 including a polarized light conversion device 130, a polarized beam splitter 200 which reflects an S-polarized light beam emerging from the polarizing illuminator 100 by an S-polarized light beam reflecting face 201, a dichroic mirror 412 which separates the blue (B) light component from the light reflected on the S-polarized light beam reflecting face 201 of the polarized beam splitter 200, a reflection liquid crystal light valve 300B modulating the separated blue (B) light component, a dichroic mirror 413 which separates a red (R) light component from the light beam not containing the blue light component, a reflection liquid crystal light valve 300R modulating the separated red (R) light component, a reflection liquid crystal light valve 300G modulating the residual green (G) light component passing through the dichroic mirror 413, and a projection optical system 500 which includes a projection lens projecting a synthesized light on a screen 600 in which the modulated light beams from the three reflection liquid crystal light valves 300R, 300G, and 300B are combined through the dichroic mirrors 412 and 413 and the polarized beam splitter 200. The above-mentioned liquid crystal panels are used as these three reflection liquid crystal valves 300R, 300G and 300B, respectively.

[0060]

The random polarized light beams emerging from the light source 110 are divided into a plurality of intermediate light beams by the integrator lens 120, converted to single-polarization light beams (S-polarized light beam) substantially having a polarized light direction by the polarizing device 130 which has a second integrated lens at the light incident side, and are incident on the polarized beam splitter 200. The S-polarized light beams emerging from the polarizing device 130 are reflected from the S-polarized light beam reflecting face 201 of the polarized beam splitter 200, the blue (B) light beam among the reflected light beams is reflected on the blue light reflecting layer of the dichroic mirror 412 and modulated by the reflection liquid crystal light valve 300B. The red (R) light beam among the light beams passing through the blue light reflecting layer of the dichroic mirror 411 is reflected on the red light reflecting layer of the dichroic mirror 413 and modulated by the reflection liquid crystal light valve 300R.

[0061]

Further, the green (G) light beam passing through the red light reflecting layer of the dichroic mirror 413 is modulated by the reflection liquid crystal light valve 300G. In such a manner, modulated by the reflection liquid crystal light valves 300R, 300G and 300B (impossible to translate due to incomplete sentence), and the reflective liquid

crystal panel including the reflection liquid crystal light valves 300R, 300G and 300B uses a TN liquid crystal (longitudinal axes of liquid crystal molecules are substantially aligned in the direction parallel to the panel substrate when no voltage is applied) or an SH liquid crystal (longitudinal axes of liquid crystal molecules are substantially aligned in the direction perpendicular to the panel substrate when no voltage is applied).

[0062]

When a TN liquid crystal is used, in a pixel (OFF pixel) in which a voltage applied to the liquid crystal layer intervened between the reflecting electrode of the pixel and the common electrode of the opposing substrate is lower than a threshold voltage, the incident color light is elliptically polarized in the liquid crystal layer, is reflected from the reflecting electrode and emerges from the liquid crystal layer in which the polarization axis of the emerging light is shifted by approximately 90 degrees from the incident light and elliptically polarized. On the other hand, in a pixel (ON pixel) in which a voltage is applied to the liquid crystal layer, the incident color light reaches the reflection electrode without polarization, is reflected and emerged, in which the emerging light has the same polarization axis as the incident light. Since the alignment angle of the liquid crystal molecule of the TN liquid crystal varies in response to the voltage applied to the reflecting electrode, the angle of the polarization axis

of the reflected light in relation to the incident light varies in response to the voltage applied to the reflecting electrode through the transistor in the pixel.

[0063]

When an SH liquid crystal is used, in a pixel (OFF pixel) in which the voltage applied to the liquid crystal layer is lower than a threshold voltage, the incident color light reaches the reflection electrode without polarization, is reflected and emerges, in which the emerging light has the same polarization axis as the incident light. On the other hand, in a pixel (ON pixel) in which a voltage applied to the liquid crystal layer, the incident color light is elliptically polarized in the liquid crystal layer, reflected on the reflecting electrode and emerges from the liquid crystal layer in which the polarization axis of the emerging light is shifted by approximately 90 degrees from the incident light and the emerged light is elliptically polarized. Since the alignment angle of the liquid crystal molecule of the TN liquid crystal varies in response to the voltage applied to the reflecting electrode as in the TN liquid crystal, the angle of the polarization axis of the reflected light in relation to the incident light varies in response to the voltage applied to the reflecting electrode through the transistor in the pixel.

[0064]

Among the color light beams reflected from pixels in these liquid crystal panels, the S-polarized light component

does not pass through the polarized beam splitter 200 which reflects the S-polarized light and transmits P-polarized light. The light beams passing through the polarized beam splitter 200 form an image. The projected image is a normally-white display when a TN liquid crystal is used in the liquid crystal panel because the reflected light beams in OFF pixels reach the projection optical system 500 and the reflected light beams in ON pixels do not reach the lens, and a normally-black display when an SH liquid crystal is used because the reflected light beams in OFF pixels do not reach the projection optical system and the reflected light beams in ON pixels reach the projection optical system 500.

[0065]

In reflective liquid crystal panels, the pixels are formed by a semiconductor production technology the number of pixels can be increased compared to active matrix liquid crystal panels in which a TFT array is formed on a glass substrate, and the size of the panel can be reduced. High density images can therefore be projected and projectors can be miniaturized.

[0066]

As shown in Figure 7, the peripheral circuit section of the liquid crystal panel is covered with the light shielding film, and the same voltage (for example, the LC common voltage; if the LC common voltage is not used, the peripheral counter electrode is separated from the counter

Received at: 5:25AM, 8/10/2002

electrode in the pixel since the common voltage differs from the voltage of the counter electrode in the pixel) is applied to the peripheral circuit section and the counter electrode formed at the position in which the opposing substrate is opposed. Almost zero volt is therefore applied to the liquid crystal intervened between them and the liquid crystal is the same as an OFF state. As a result, in the TN liquid crystal panel the periphery of the image region exhibits an entire white display in response to the normally-white display, whereas in the SH liquid crystal panel the periphery of the image region exhibits an entire black display in response to the normally-black display.

[0067]

Further satisfactory results are obtained when the silicon oxide forming the passivation film of the light valve 300R as the first reflective liquid crystal panel modulating red light separated by the polarized beam splitter 200 as a color separation means which separate the light from the light source 110 into three primaries has a thickness in a range of 1,300 to 1,900 angstroms, the silicon oxide forming the passivation film of the light valve 300G as the second reflective liquid crystal panel modulating green light has a thickness in a range of 1,200 to 1,600 angstroms, and the silicon oxide forming the passivation film of the light valve 300B as the third reflective liquid crystal panel modulating blue light has a thickness in a range of 900 to 1,200 angstroms.

[0068]

In accordance with the above-mentioned embodiment, a voltage applied to each of pixels in the reflective liquid crystal panels 300R, 300G and 300B is sufficiently retained and the pixel electrode has a significantly high reflectance, resulting in clear projected images.

[0069]

Figure 15 includes views illustrating appearances of electronic devices using the reflective liquid crystal panels in accordance with the present invention. In each electronic device, the reflective liquid crystal panel is used as a direct viewing-type reflective liquid crystal panel, not as a light valve which is used together with a polarized beam splitter. The reflecting electrode must therefore not be a perfect mirror surface and preferably has adequate unevenness in order to expand the viewing angle. Other configurations are basically the same as the light valve.

[0070]

Figure 15(a) is an isometric view of a portable telephone. Identification number 1000 represents a portable telephone main body, and identification number 1001 represents a liquid crystal display using a reflective liquid crystal panel in accordance with the present invention.

Figure 15(b) shows a watch-type electronic device. Identification number 1100 is an isometric view of a watch

main body. Identification number 1101 represents a liquid crystal display using a reflective liquid crystal panel in accordance with the present invention. Since the liquid crystal panel has high definition pixels compared to conventional watch displays and is capable of displaying television images, a watch-type television can be achieved.

[0071]

Figure 15(c) shows a portable information processing unit, e.g. a word processor or a personal computer. Identification number 1200 represents an information processing unit, identification number 1202 represents an input section such as a keyboard, identification number 1206 represents a display using a reflective liquid crystal panel in accordance with the present invention, and identification number 1204 represents an information processing unit main body. Since these electronic devices are driven by batteries, the use of the reflective liquid crystal panel having no light source lamp can lengthen the battery life. Since the peripheral circuits can be stored in the panel substrate, significant reduction of parts, and weight and size reduction can be achieved.

[0072]

In the above-mentioned embodiments, although a TN type and a homeotropic alignment SH type are exemplified as a liquid crystal of the liquid crystal panel, other types of liquid crystals are also available.

[0073]

[Advantages]

As described above, a reflective liquid crystal panel substrate in accordance with the present invention is provided with a passivation film, and thus has improved reliability. The use of a silicon oxide film having a thickness of 500 to 2,000 angstroms as the passivation reduces dependence of reflectance of the pixel electrode on variation of the thickness. In particular, the silicon oxide film having a thickness of 500 to 2,000 angstroms exhibits slight dependence of the reflectance on the wavelength and thus can reduce variation of the reflectance.

[0074]

The thickness of the silicon oxide film as the passivation film is set to an adequate range in response to the wavelength of the incident light, e.g. 900 to 1,200 angstroms for a pixel electrode reflecting blue light, 1,200 to 1,600 angstroms for a pixel electrode reflecting green light, and 1,300 to 1,900 angstroms for a pixel electrode reflecting red light. Variation of the reflectance in each color can therefore be suppressed to 1% or less. As a result, reliability of the liquid crystal panel can be improved, and the image quality of a projection display device using the reflective liquid crystal panel as a light valve can be improved.

[0075]

Since the thickness of the silicon oxide film as the passivation film is determined in response to the thickness

of the alignment film formed thereon and the thickness of the alignment film is set to a range of 300 to 1,400 angstroms, variation of the refractive index of the liquid crystal can be effectively prevented.

[0076]

In a reflective liquid crystal panel in which a pixel region comprising a matrix of pixel electrodes and peripheral circuits, such as a shift resistor and a control circuit, provided outside the pixel region are formed on the same substrate, a passivation film composed of a silicon oxide film is formed above the pixel region and a passivation film composed of a silicon nitride film is formed above the peripheral circuits. The use of the silicon nitride film above the peripheral circuits further insures protection of the peripheral circuits and improves reliability.

[0077]

A silicon nitride film is provided as an insulating interlayer between the reflecting electrode and a metal layer thereunder instead of the passivation film above the reflection electrode or together with the passivation film composed of the silicon oxide film. The moisture resistance is therefore improved, a MOSFET for pixel switching and a holding capacitor can be prevented from corrosion due to water or the like.

[0078]

A monolithic protective structure in which a silicon

nitride film is formed on a passivation film composed of a silicon oxide film is provided over the edge and side wall of a laminate of an insulating interlayer formed at the periphery of the pixel region and a metal layer shielding the periphery. The waterproof property at the edge of the liquid crystal panel in which water readily penetrates is therefore improved and durability is also improved due to its reinforcement effect.

[Brief Description of the Drawings]

[Figure 1]

A cross-sectional view of a first embodiment of a pixel region of a reflecting electrode side substrate of a reflective liquid crystal panel in accordance with the present invention.

[Figure 2]

A cross-sectional view of an embodiment of a structure of a peripheral circuit of a reflecting electrode side substrate of a reflective liquid crystal panel in accordance with the present invention.

[Figure 3]

A planer layout of a first embodiment of a pixel region of a reflecting electrode side substrate of a reflective liquid crystal panel in accordance with the present invention.

[Figure 4]

A cross-sectional view of an embodiment of an edge structure of a reflecting electrode side substrate of a

reflective liquid crystal panel in accordance with the present invention.

[Figure 5]

A cross-sectional view of another embodiment of a reflecting electrode side substrate of a reflective liquid crystal panel in accordance with the present invention.

[Figure 6]

A plan view of an example of a layout of a reflecting electrode side substrate of a reflective liquid crystal panel in an embodiment.

[Figure 7]

A cross-sectional view of an embodiment of a reflective liquid crystal panel using a liquid crystal panel substrate of an embodiment.

[Figure 8]

A graph including a gate driving waveform and a data line driving waveform of an FET for pixel electrode switching of a reflective liquid crystal panel in accordance with the present invention.

[Figure 9]

A block diagram of a video projector as an example of projection display devices in which a reflective liquid crystal panel of an embodiment is used as a light valve.

[Figure 10]

A graph illustrating that the reflectance of a reflecting electrode composed of an aluminum layer varies with the thickness of the silicon oxide film at a given

length of the incident light.

[Figure 11]

A graph illustrating that the reflectance of a reflecting electrode composed of an aluminum layer varies with the thickness of the silicon oxide film at a given length of the incident light.

[Figure 12]

A graph in which the reflectance is plotted at a given wavelength interval when the thickness of the silicon oxide film is changed within a wavelength range covering blue light.

[Figure 13]

A graph in which the reflectance is plotted at a given wavelength interval when the thickness of the silicon oxide film is changed within a wavelength range covering green light.

[Figure 14]

A graph in which the reflectance is plotted at a given wavelength interval when the thickness of the silicon oxide film is changed within a wavelength range covering red light.

[Figure 15]

(a), (b) and (c) are appearances of electronic devices using reflective liquid crystal panels in accordance with the present invention, respectively.

[Reference Numerals]

1 semiconductor substrate

2 well region

3 field oxide film

4 gate line

4a gate electrode

5a, 5b source/drain regions

6 first insulating interlayer

7 data line (first metal layer)

8 P-type doping region

9a electrode of a holding capacitor (conductive layer)

9b insulating film as a conductor of a holding capacitor

10 auxiliary bonding wire

11 second insulating interlayer

12 light shielding layer (second metal layer)

13 third insulating interlayer

14 pixel electrode (third metal layer)

15 connecting plug

16 contact hole

17 passivation film

20 pixel region

21 data line driving circuit

22 gate line driving circuit

23 input circuit

24 timing control circuit

25 light shielding layer (third metal layer)

26 pad region

31 liquid crystal panel substrate

32 supporting substrate

33 counter electrode

35 glass substrate at the incident side

36 sealing material

37 liquid crystal

70 power source line

71 contact hole

80 P-type contact region

110 light source

200 polarized beam splitter

300 light valve (reflection liquid crystal)

412, 413 dichroic mirror

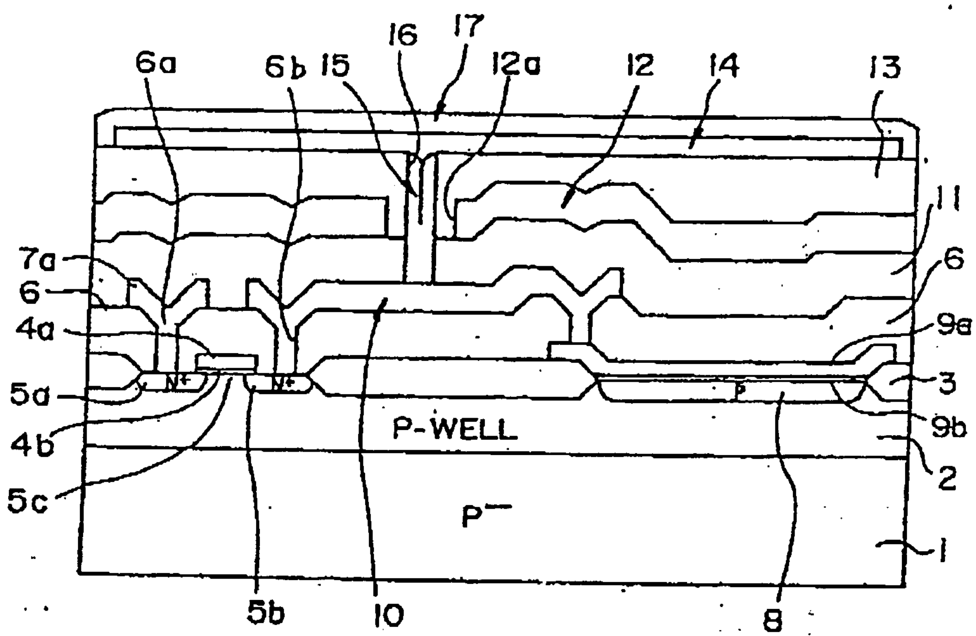
500 projection optical system

600 screen

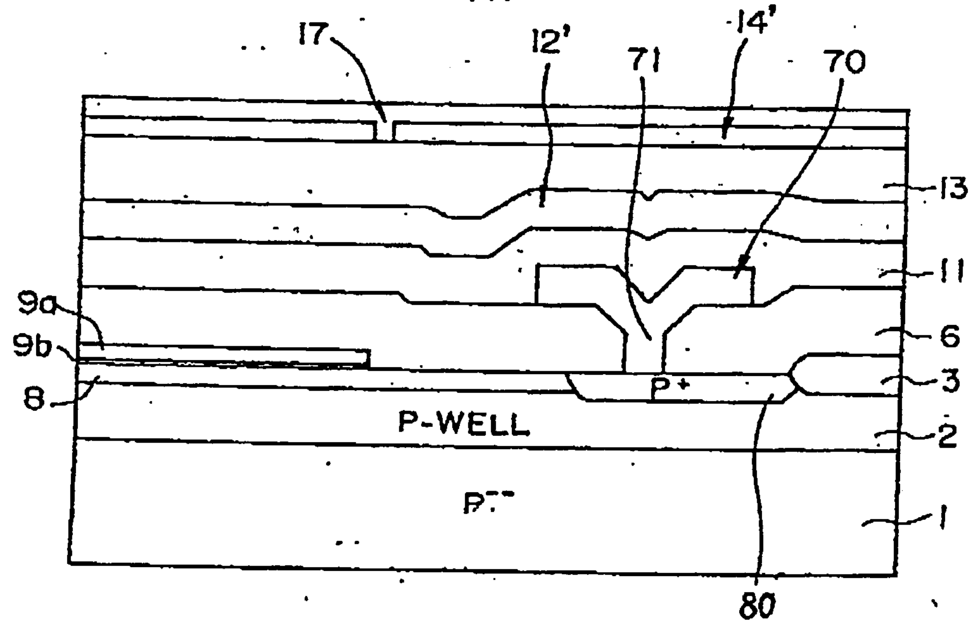
[Name of Document] Drawings

[Figure 1]

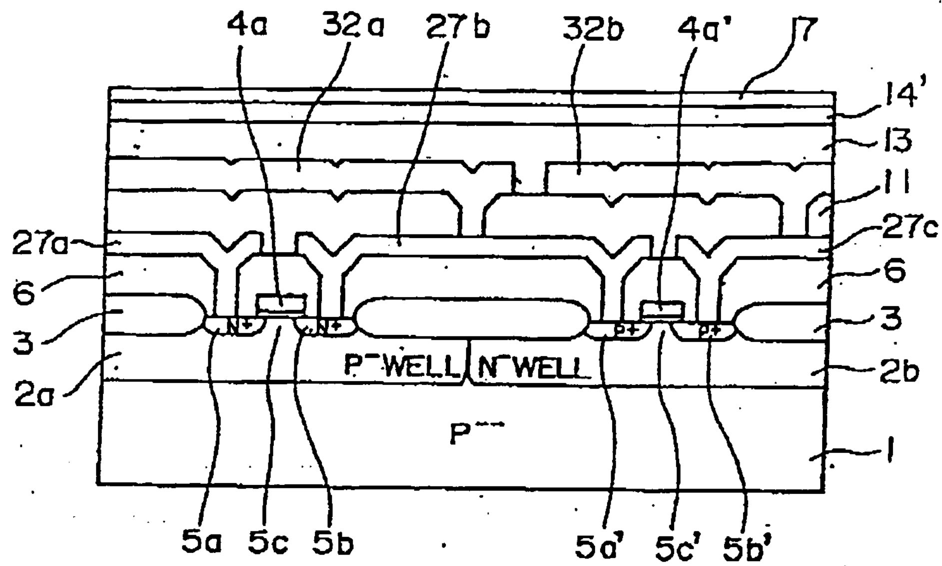
(a)



(b)



[Figure 2]


4a
32a
27b
32b
4a'
17
14'
13
11
27a
27c
6
6
3
3
2a
2b
N+
N+
P+
P+
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N⁻WELL
P⁻⁻
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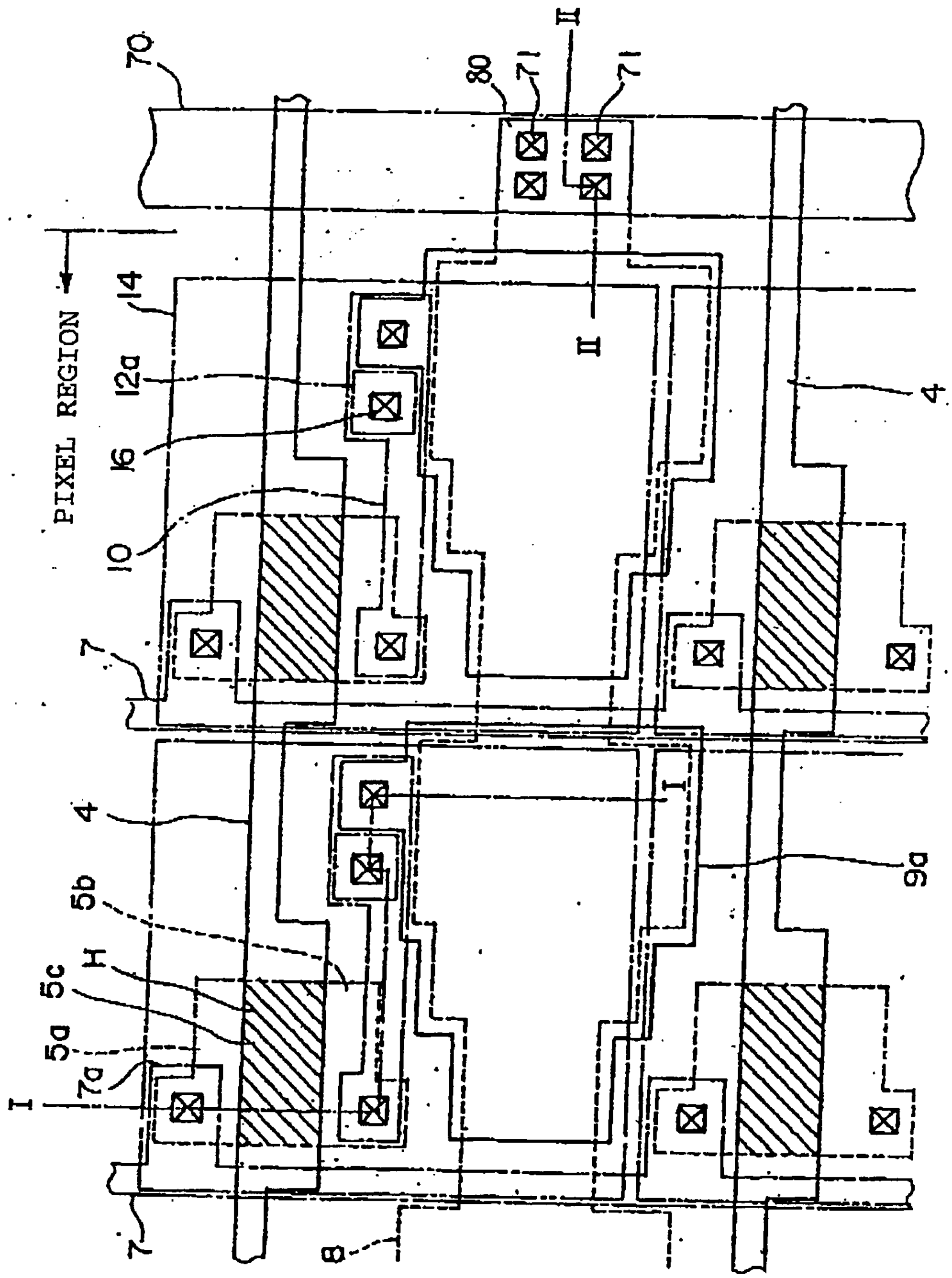
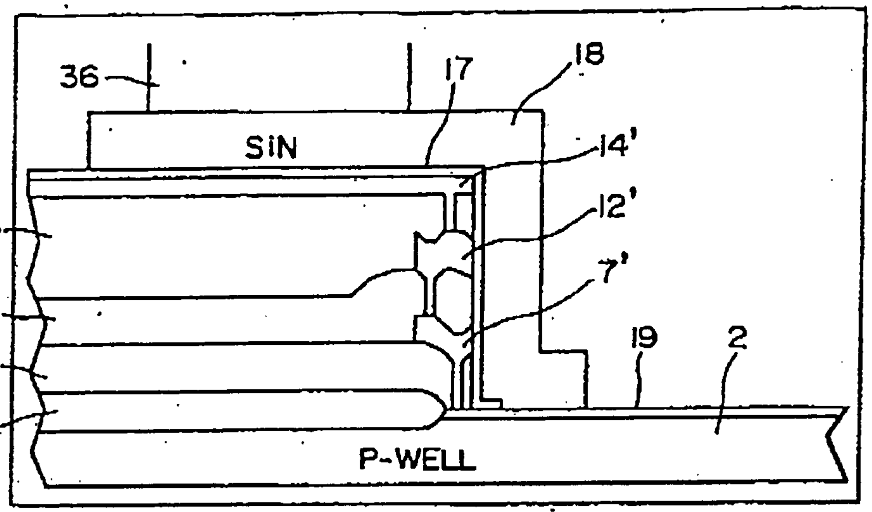
5a
5c
5b
5a'
5c'
5b'

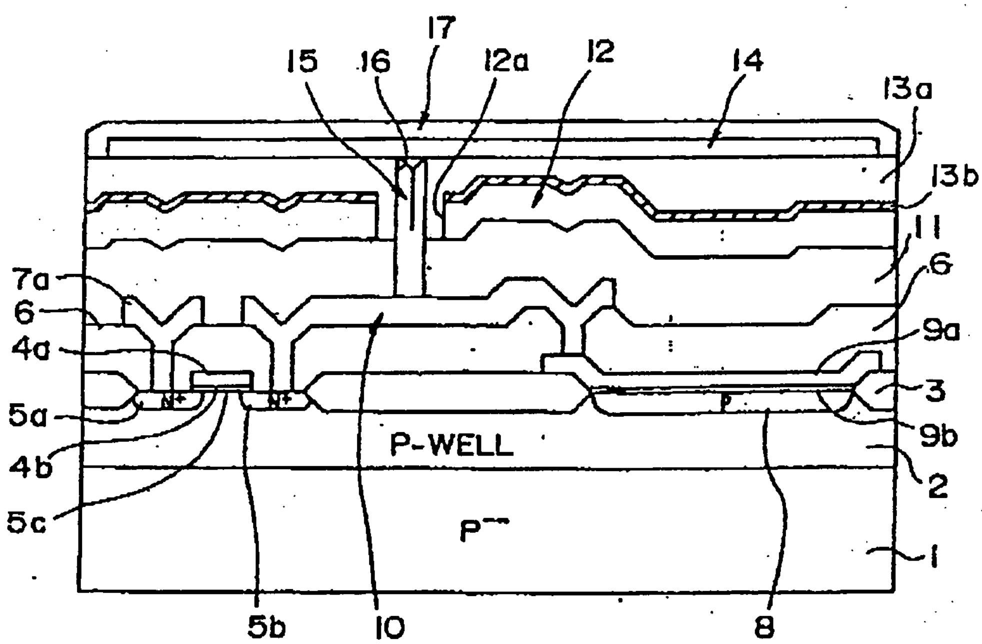
[Figure 3]


70
80
71
71
II
II
PIXEL REGION
14
12a
16
10
7
4
4
9a
5b
H
5c
5a
7a
I
I
7
8

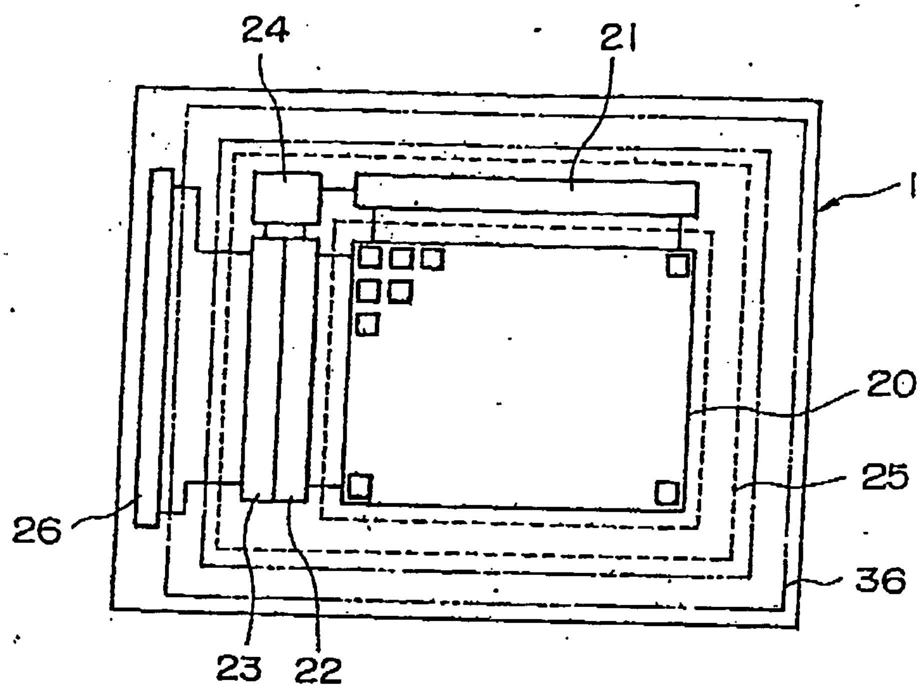
[Figure 4]



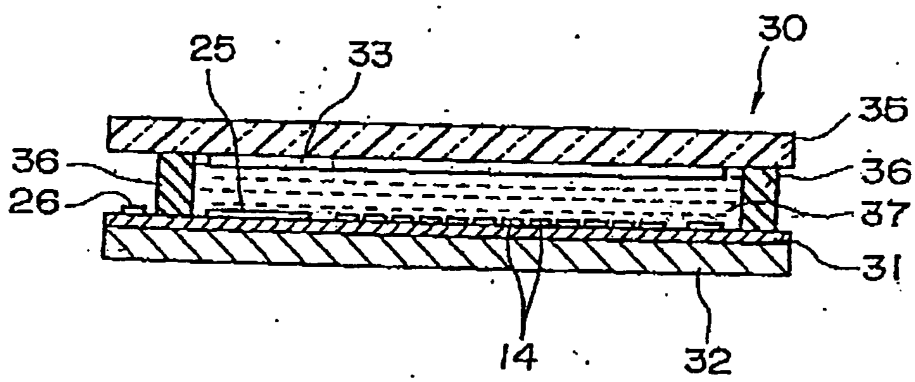
[Figure 5]



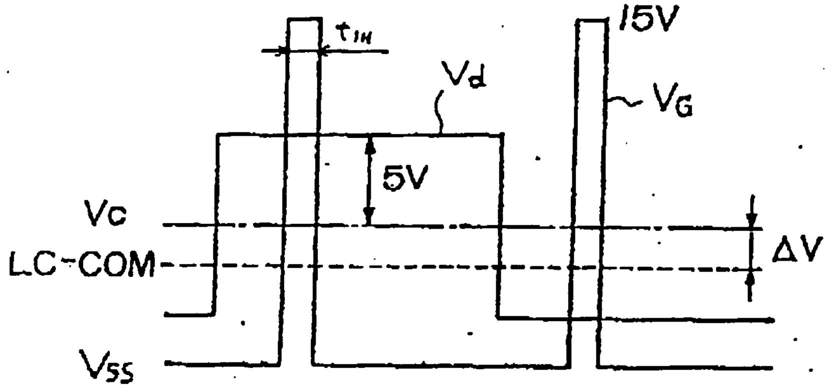
[Figure 6]



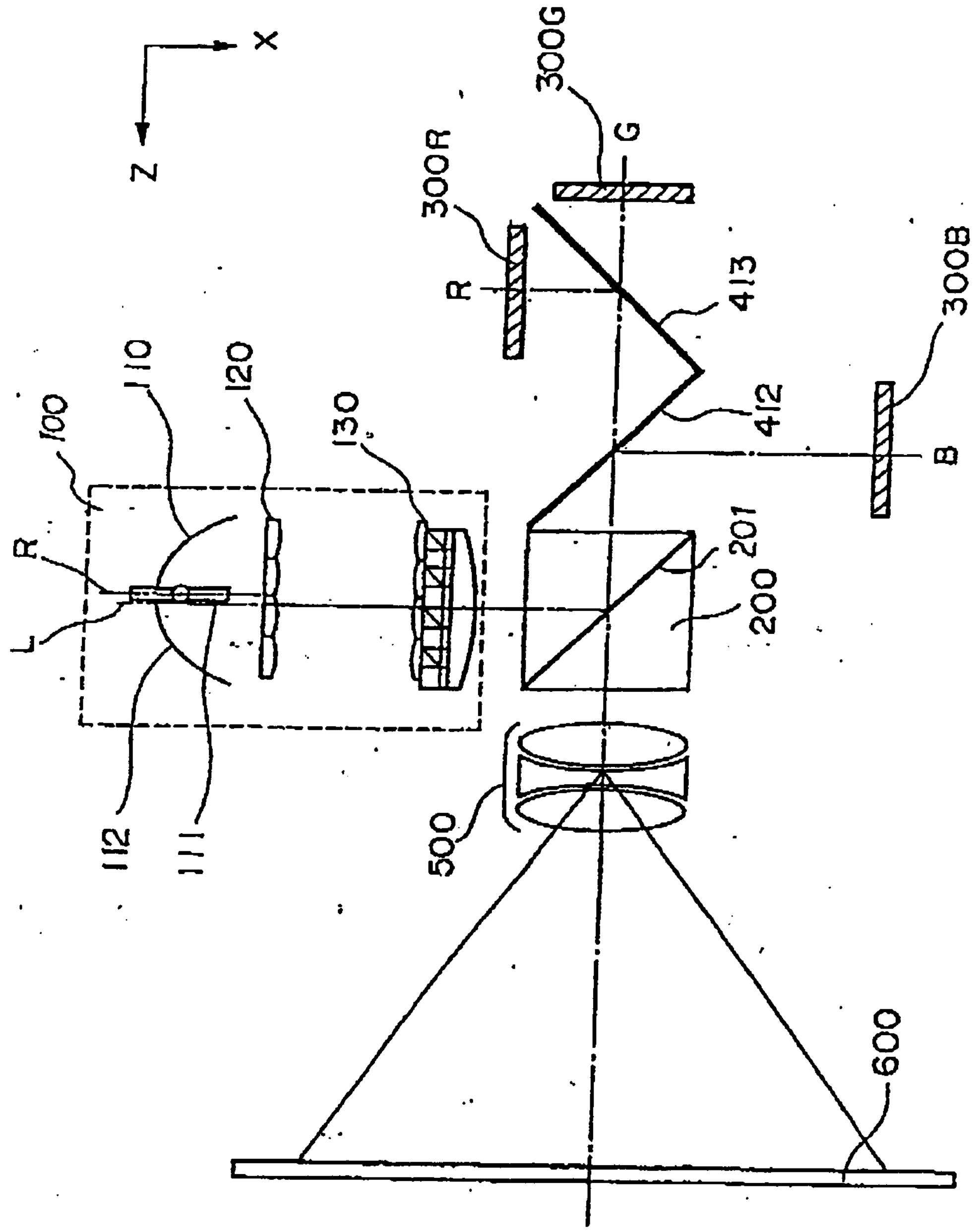
[Figure 7]



[Figure 8]



[Figure 9]


X
Z
300G
G
300R
R
413
412
300B
B
100
110
120
130
R
L
201
200
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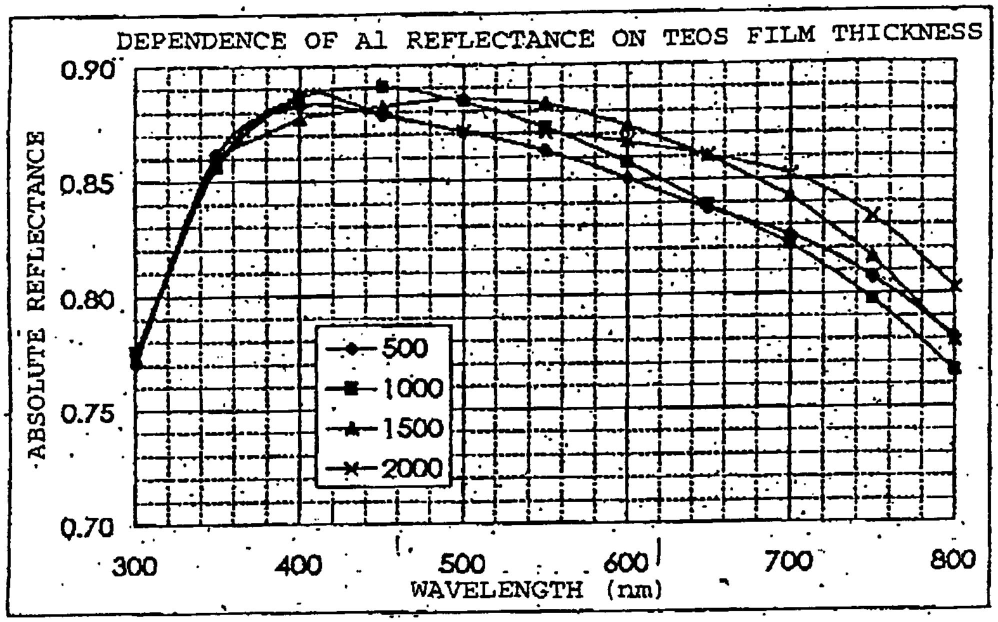
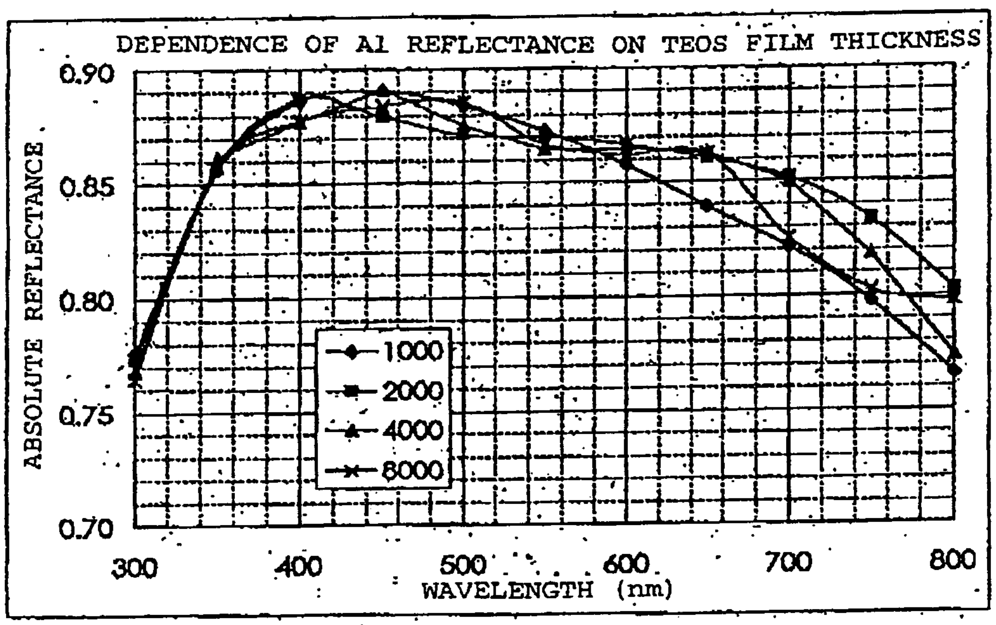
112
111
600

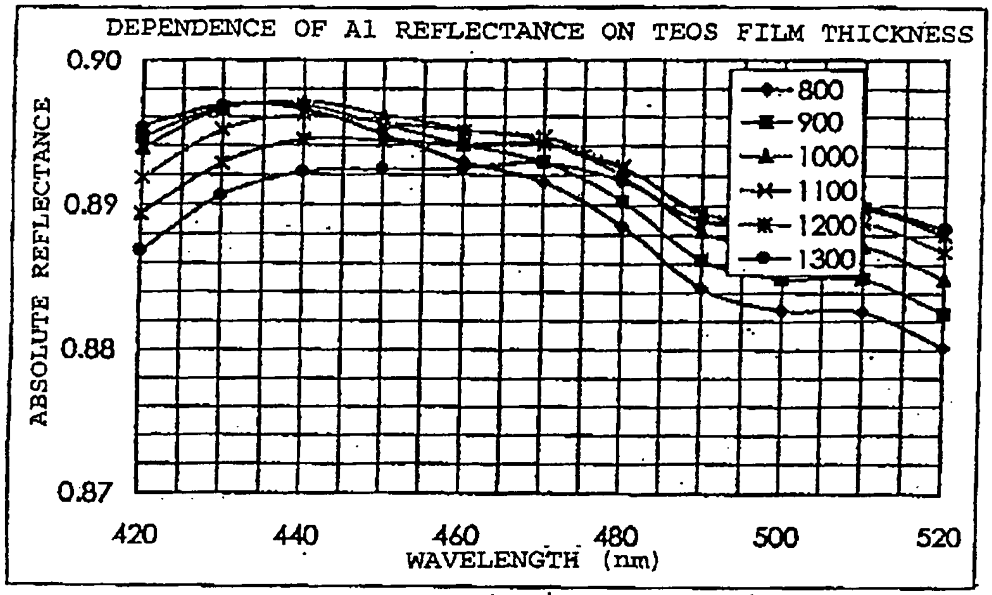
[Figure 10]



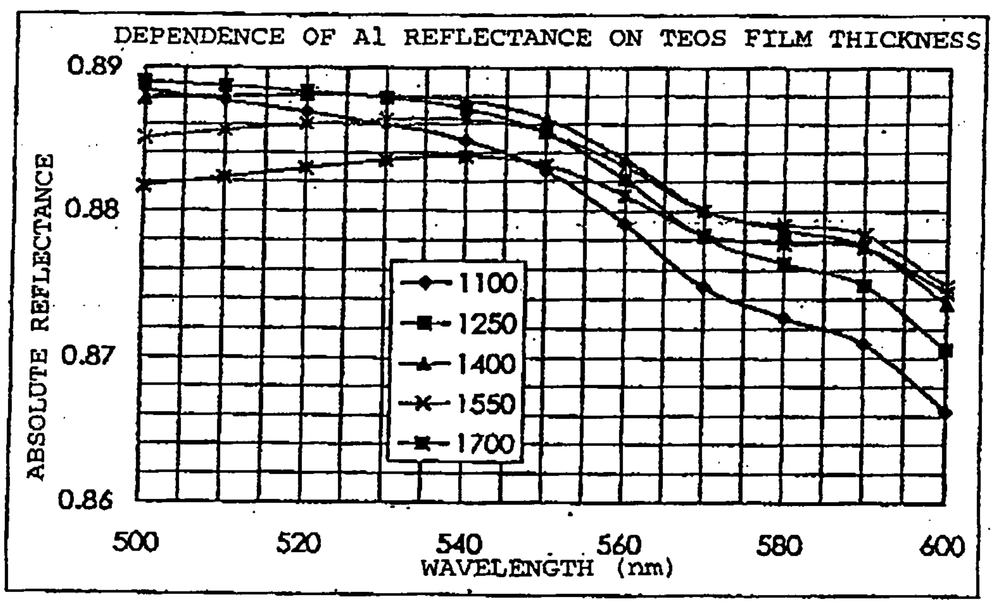
[Figure 11]



[Figure 12]



[Figure 13]



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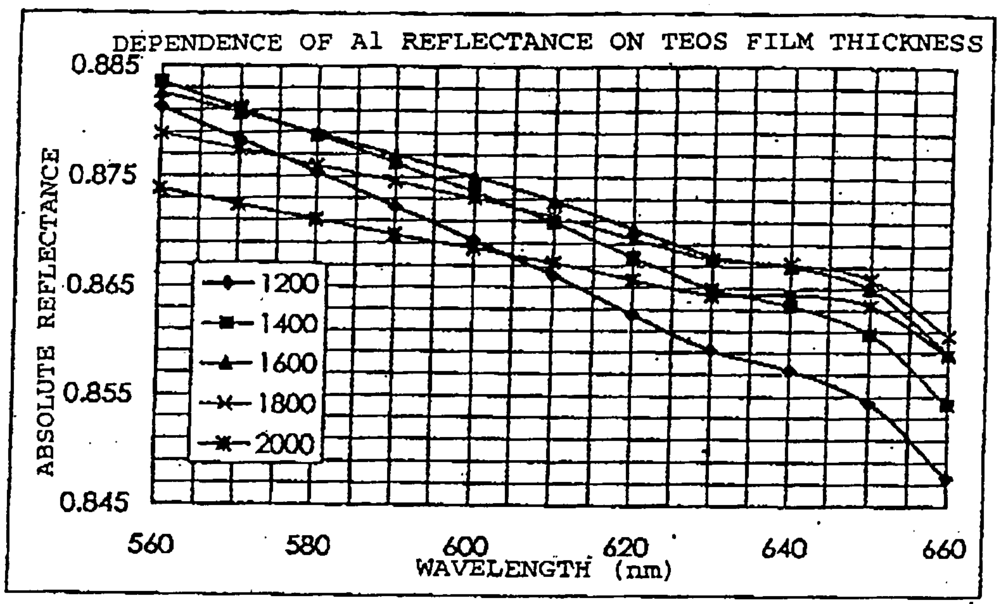
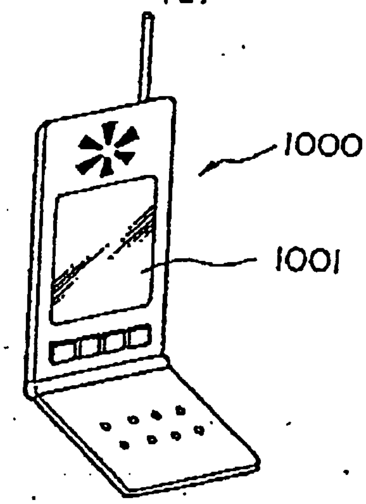
[Figure 14]

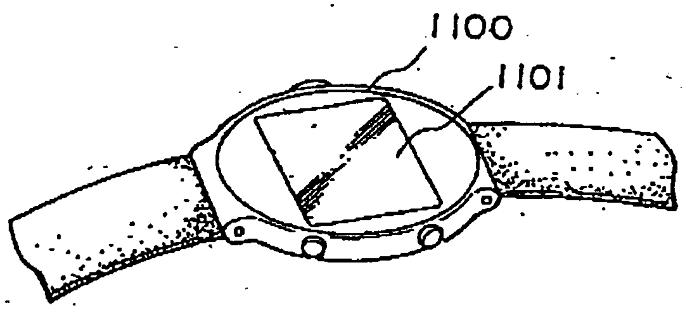


[Figure 15]

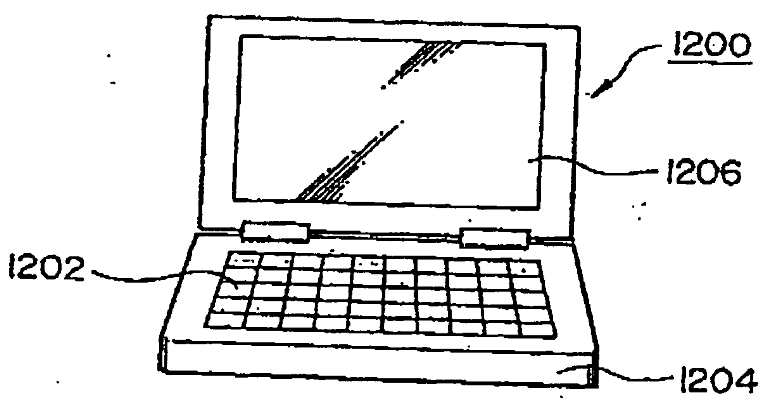
(a)



(b)



(c)



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[Name of Document] Abstract

[Abstract]

[Problem] A silicon nitride film which is formed by a reduced pressure CVD process and generally used as a passivation film in semiconductor devices has a thickness variation of approximately 10%. In a reflective liquid crystal panel using the same, reflectance significantly varies or refractive index of the liquid crystal varies due to the variation of the thickness of the passivation film.

[Solving Means] In a liquid crystal substrate in which a matrix of reflecting electrodes (14) is formed on a substrate (1), a transistor is formed in response to each reflection electrode and a voltage is applied to the reflecting electrode through the transistor, a silicon oxide film having a thickness of 500 to 2,000 angstroms is used as the passivation film and the thickness is set to an adequate value in response to the wavelength of the incident light.

[Selected Drawing] Figure 1